Extreme precipitation in the Southeast US: HMT-Southeast's specialized observations and modeling focus on high-impact forecast challenges

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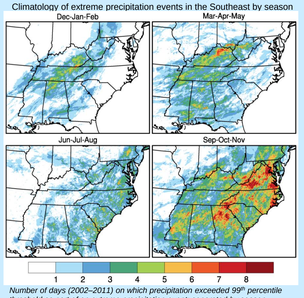
HMT-Southeast: Project background and motivation

Extreme precipitation in the southeast U.S.:

- Southeast U.S. experiences extreme rainfall during all seasons
- Large variability in types of weather systems capable of producing flooding; region comprised of both coastal and mountainous terrain
- Known regional challenges exist for quantitative precipitation forecasting (QPF) and estimation (QPE) – especially for extreme precipitation



Number of days (2002–2011) on which precipitation exceeded 99th percentile threshold as part of an extreme precipitation event, separated by season

NOAA's Hydrometeorological Testbed:

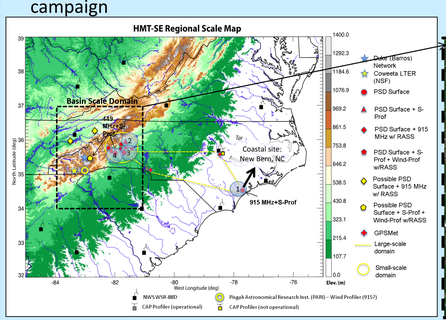
Advancing and improving extreme precipitation forecasts

- HMT conducts research on precipitation and weather conditions that can lead to flooding
- Fosters transition of scientific advances and new tools into forecasting operations
- Accelerates development and prototyping of advanced hydrometeorological observations, models, and physical process understanding

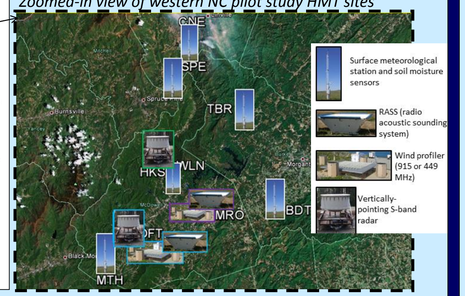
Flooding in Atlanta, GA (2009) and Nashville, TN (2010)

HMT-Southeast Pilot Study (HMT-SEPS)

- HMT-Southeast Pilot Study (HMT-SEPS) deployment May 2013 – October 2014
- QPE, instrumentation focus in western North Carolina (some instrumentation in central, eastern NC)
- NOAA bringing instruments to region, leveraging additional assets from NASA ground validation campaign



Zoomed-in view of western NC pilot study HMT sites



The HMT-Southeast Pilot Study instrumentation will include:

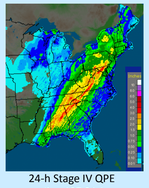
- 4 profiling radars (including a site with 449 MHz for wind profiling with RASS and S-band for precipitation vertical structure). Each site will measure surface temperature, relative humidity, pressure, wind, and precipitation, as well as use a NOAA parsival disdrometer for drop size distribution measurements
- 6 surface sites in the Upper Catawba basin with standard meteorology sensors (temperature, relative humidity, pressure, wind, redundant precipitation measurements using a combination of NOAA and NASA gauges, and one or more NASA disdrometers) as well as soil moisture and temperature (up to 5-levels)
- Raleigh, NC CAP 915 MHz profiler (owned and operated by North Carolina Division of Air Quality) was repaired and upgraded (planned to be operational April 2013)
- Charlotte, NC CAP 915 MHz profiler (owned and operated by North Carolina Division of Air Quality) software to be upgraded to provide improved clutter and melting level detection. A nearby GPS receiver will provide integrated water vapor measurements.

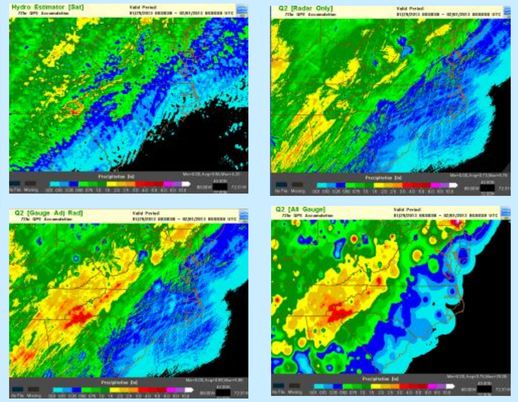
Quantitative Precipitation Estimation (QPE): Regional challenges and HMT-SEPS goals

HMT-SEPS QPE objectives:

- Evaluate and improve QPE systems (e.g., MPE, MRMS, Stage IV), by focusing on:
  - intelligent integration of multi-sensor QPE information for gauges, radars, and satellite;
  - infrared (IR) and microwave satellite QPE products (CMORPH, SCaMPR, Hydro-Estimator, TRMM 2A25 and 3B42) with ground-based QPE;
  - 4-D structure of precipitation and variability of the drop size distribution (DSD) with resulting impact on QPE systems (e.g., appropriate Z-R (selection);
  - impact of gap-filling radars on QPE systems
- Evaluate NWS radar-rainfall algorithms
- Provide observational ground validation data for use in NOAA Global Precipitation Measurement (GPM) Proving Ground

QPE challenge example: 28 Jan – 1 Feb 2013 Flooding in Asheville, NC


24-h Stage IV QPE ending 12Z 31 Jan



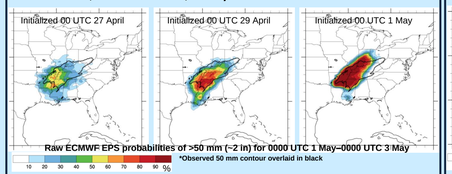
72-hour QPE (00Z 29 Jan – 00Z 1 Feb 2013) comparisons using different National Mosaic and Multi-sensor QPE products (NMQ; http://nmq.ou.edu/)

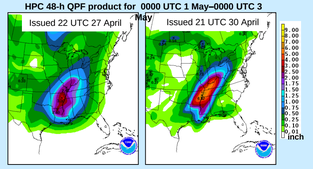
Forecasting extreme precipitation: QPF Strengths and challenges

HMT-SE QPF objectives

- Analyze climatology and event classifications toward improving understanding of large-scale and mesoscale dynamics associated with extreme precipitation;
- Improve understanding of region-specific physical processes impacting extreme event QPF;
- Facilitate researcher and forecaster collaboration to
  - (i) clarify processes/environmental parameters affecting extreme precipitation;
  - (ii) identify human and model QPF challenges; and
  - (iii) identify new or improved tools, definitions and classifications to connect relevant research findings to benefit operational forecasting

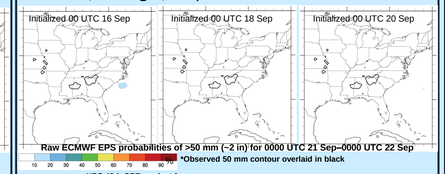
Forecast success/high predictability example : Nashville, Tennessee, May 2010

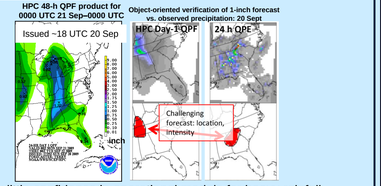




- Several days in advance of event forecast models and forecasters identified potential for heavy rain event in the central/southern Mississippi Valley region
- QPF generally matched by observed precip (though amounts under-predicted)
- Axis of heaviest forecasted rainfall consistently west of observed axis

Forecast challenge/low predictability example: Atlanta, Georgia, September 2009





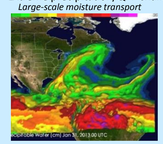
- Very little confidence in operational models for heavy rainfall potential
- Low NWP confidence reflected in human-generated forecasts at NCEP/HPC and Peachtree City NWS office
- Meteorological set-up had little predictability – focusing of heaviest precipitation strongly impacted/driven by small-scale processes and interactions in a "weakly-forced" synoptic environment

HMT-SE QPF research (ongoing):

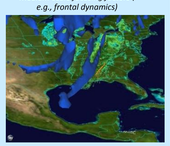
- Extreme precipitation climatology: identifying environmental parameters, high- and low-predictability event types
- QPF verification of operational forecasts, HMT-Ensemble (9 members; http://esrl.noaa.gov/gsd/fab/) to identify forecast challenges
- Model-based case study sensitivity studies on Tennessee, Georgia events, HMT-SEPS events as they occur
- Planned: incorporation of HMT-SEPS, NASA observational data into model predictability improvement studies

Extreme precipitation/QPF challenge research areas

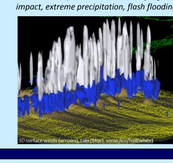
Large-scale moisture transport



Medium-scale focusing factors (e.g., frontal dynamics)



Small-scale processes as drivers of high-impact, extreme precipitation, flash flooding



Summary

- The Southeast U.S. experiences extreme precipitation from a number of different phenomena, making quantitative precipitation estimation (QPE) and forecasting (QPF) in this region especially challenging.
- HMT-SEPS afford an opportunity for QPE improvement-focused community collaboration by providing a common dataset for QPE algorithm development inter-comparison.
- Analysis of a regional extreme precipitation climatology and contrasting key environmental differences between extreme precipitation event types and forecast skill offers potential for enhancing forecaster situational awareness of both events themselves and operational NWP model challenges and shortcomings.
- Community collaboration, communication, and the effective leveraging of common interests and capabilities will help to achieve the QPE and QPF goals of HMT-SEPS

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The U.S. Weather Research Program
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